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Pancreatic Cancer: Total Costs and Utilization of Health Services

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Background and Objectives: Pancreatic cancer ranks 11th in incidence, and fifth in cancer deaths, with 29,000 affected annually. Accurate estimates of the cost of pancreatic cancer are unavailable; existing estimates are variable or not generalizable. This paper presents detailed cost estimates for pancreatic cancer by service, age, and gender.
Methods: Direct and indirect societal costs are determined using a prevalence-based, human capital approach.
Results: Total annual costs are $4.9 billion, (men: $3.0 billion, women: $1.9 billion). Total direct costs are $881 million, with 71% ($627.1 M/$881.3 M) for those over 65 years. Total hospital costs are 77% ($679.5 M/$881.3 M) of total direct costs. Total indirect costs are $4.0 billion, with 63% ($2,518.43 M/$4,018 M) for those 45 to 64 years. Mortality costs are $3.7 billion, 93% ($3,739 M/$4,018 M) of indirect costs.
Conclusions: This paper presents cost estimates that are precise and generalizable to the general population. The surgical cost burden may be less than indicated previously, with most hospitalizations not including a major procedure, and average operating room costs accounting for only 9% ($1,045/$11,055) of hospital costs. Women have significantly less cancer-directed surgery than men.
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KEY WORDS: **pancreas; surgery; cancer; cost; economics; methodology; epidemiology**

INTRODUCTION

Pancreatic cancer is the fourth and fifth leading cause of cancer deaths for men and women respectively, and the 11th in cancer incidence in the U.S. [1]. The incidence is about 10.9/100,000 and has changed little since 1973. The mortality rate is about 8.4/100,000 for the 1970 standard U.S. population [2]. Statistics published by the SEER program show that the relative survival rate for all diagnosed pancreatic cancer at 5 years is only 4–5% for all stages, 12–13% when localized, and only 2% when diagnosed at a distant stage [1]. The 5-year survival rate for histologically confirmed disease is about half this [2]. Despite its low incidence and prevalence, a high cost burden of pancreatic cancer is expected because of the high mortality, and the complex surgical procedures used in treatment.

This study estimates the direct and indirect costs of pancreatic cancer in the U.S. in 1996 using a prevalence-based, aggregate, human capital approach. It is the first published study of the costs of pancreatic cancer by service, age group, and gender. Pancreatic cancer is an important area for cost analyses for several reasons. First, there is controversy over the overall survival value and cost-effectiveness of cancer-directed surgery, especially in the later stages [1,3]. Second, there are new and potentially effective chemotherapeutic agents for pancreatic cancer (gemcitabine, camptothecins, and taxanes), which may affect both the costs and quality of life of cancer patients [4]. Accurate estimates of the costs and cost-effectiveness of pancreatic cancer diagnosis and treatment are needed to demonstrate the cost-effectiveness of various treatment choices. A detailed cost estimate will

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assist in planning by public and private payers and especially by comprehensive cancer and chemotherapy centers, which consolidate cancer care under a capitated plan [5–7]. The diagnosis and management of pancreatic cancer continues to evolve [3], making it important to examine the current cost burden of this disease.

Existing cost estimates of pancreatic cancer focus either on the net benefit of a particular workup or treatment [8–14], or are general studies of overall costs without epidemiological detail [15]. Existing studies have compared the cost-effectiveness of different specific diagnostic or treatment protocols [7–12], but the costs vary and are institutionally specific or use charges. Despite the interest in pancreatic cancer costs, only one study determined the costs of pancreatic cancer, yet presented neither epidemiological or service-specific data on which its costs were based [15].

MATERIALS AND METHODS

Design

A prevalence approach was used to estimate the average annual direct medical and indirect economic costs of pancreatic cancer. Costs include the value of resources used for medical care, resources forgone due to time lost from work, housekeeping, and normal activities, and costs of early mortality. Indirect costs of morbidity and mortality were evaluated using the human capital methodology. All utilization figures and costs were updated to the 1996 population using the census rates, and to 1996 costs using the CPI for medical services. High and low case bounds were used for sensitivity analysis around the base case of best estimates.

Prevalence Data

Pancreatic cancer was defined as ICD9-CM 157, which includes endocrine and exocrine cancers. Inclusion of endocrine cases will slightly overestimate prevalence, survival, and costs, but was chosen because it consistently represents the definitions used in the health care utilization and cost data sources and therefore will give the best estimate of per capita costs (see Discussion). Cancer incidence statistics are from the 1979–1993 Surveillance, Epidemiology, and End Results (SEER) public use database [16]. Survival rates are from the SEER portable survival system [2]. We used actuarial survival rates for all diagnosed pancreatic cancer, rather than only for histologically confirmed cases, because with the relatively low rate of histological confirmation, we believe the use of all diagnoses gives a closer approximation of societal costs.

This study uses annual period prevalence to measure the number of people with the disease in the population, in contrast to the more commonly used point prevalence. Point prevalence measures the number of cases that exist at a point in time; while period prevalence measures the number of people, both alive and deceased, who have had the disease within a certain time interval. Point prevalence (12,562 persons) is much smaller than period prevalence (41,637 persons annually) in the case of pancreatic cancer because it has a very low survival rate. Only period prevalence will allow the cost per case to include costs of those who die within the annual period. We calculated age-specific annual period prevalence by adding age-specific point prevalence and age-specific annual cumulative incidence [17]. Age-specific annual cumulative incidence was calculated using SEER age-specific incidence rates and 1996 midyear U.S. census population estimates [18]. Age-specific point prevalence was calculated using a life table method, using age-specific annual cumulative incidence and the annual probability of survival for up to 10 years from diagnosis.

Medical Cost Data

Direct medical costs are estimated by service type: hospitalization (including hospital stays and physician hospital visits), outpatient costs (including physician visits, laboratory tests, medications, transportation, medical equipment and supplies, and personal care), and home and long-term care (including home, hospice, and long-term care). The estimates are broken down by gender and age groups: young (<45 years), middle (45–64 years), and old (>64 years). Indirect costs are mortality costs and morbidity costs for the unemployed (activity days lost), and for the employed (work loss).

Hospitalization

Hospitalization rates and costs for the base case were calculated using an average of three data sources, depending on the age group. Detailed estimates of rates and costs were estimated from the 1995 Maryland state database [19], which is considered one of the most stable estimates of hospital costs by diagnosis and had an adequate sample size. Maryland charge data were reduced to costs using case-weighted hospital-specific cost to charge ratios [20]. Medicare 1995 data [21], and Medi-Cal data [22] for 1996 paid claims (a proxy for costs) for hospitalizations for pancreatic cancer were also used for the relevant age groups.

The young age group was from Maryland data only, the middle age group from an average of Maryland and Medi-Cal data, and the old age group from an average of Maryland and Medicare data.

Hospital inpatient physician visits were estimated by assuming one visit for each day of hospitalization using the Maryland average length of stay. Costs were applied to these visits using the Medicare fee schedule rates by specific CPT codes, accounting for the type and complexity of visits [23].

Outpatient Care

Physician visits. Outpatient physician visit costs were estimated using specific CPT codes from the National Medicare fee schedule [23]. Total outpatient visits were estimated using the pooled National Ambulatory Medical Care Surveys (NAMCS) from 1990 to 1994 [24,25], and the National Hospital Ambulatory Medical Care (NHAMCS) surveys from 1993 to 1995 [26] for the low case estimate. Visits for any diagnosis of pancreatic cancer from National Health Interview Survey (NHIS) [27] were used as the high case estimate, since this will overstate the visit rate. The base case was an average of the high and low estimates.

Prescription medicines and other costs. Annual drug costs and other outpatient costs (laboratory tests, transportation, equipment, supplies, and personal care) were obtained from Medi-Cal claims data for all ages.

Hospice, Home, and Long-Term Care

Hospice. Medicare data were used for both the base and high case estimates for all ages. Utilization and costs by ICD-9 obtained from a large home care/hospice organization in California were used for the low case estimate [28]. The California hospice data showing that 12% (8,200/68,333) of total VNA visits, or 8,200 visits, were for hospice care; and that 3.7% (61/1,656) of their annual admissions into hospice care were for pancreatic cancer patients, were applied nationally.

Home care. National statistics for home care utilization are not available by ICD-9 (Statistics from VNA of America's database, personal communication, Sheril Banks VNAA—Denver, Co., 4/28/97). Therefore, home care utilization was estimated using state-based data from the California regional Visiting Nurses Association (VNA) data which showed that 88% (60,133/68,333) of total VNA visits were for home care visits, and that 0.1% (60/60,133) of home care visits, or 11,238 annual visits, were for pancreatic patients. These proportions were applied nationally to estimate home care utilization.

The costs of home care visits were obtained from Medicare and Medi-Cal, depending on the age group. The low case home care cost estimates were based on Medi-Cal data for the young and middle age groups, and Medicare for the old age group, since these are the age groups that are predominantly insured by these programs. The high case used only Medi-Cal data, because Medicare coverage for home care is not as comprehensive as that of Medi-Cal [29]. The base case is an average of the high and low case cost estimates.

Long-term care. Data for skilled nursing facilities were obtained from both the 1995 national Medicare data (for the base and low case estimates) and 1996 Medi-Cal data. The National Nursing Home Survey for 1995 was not used because it captured only two pancreatic cancer patients [30]. It was assumed that the elderly group uses nursing homes, and the other age groups use only hospice and home care. The high case applied Medicare costs to the elderly group and Medi-Cal costs to the 45–64-year age group.

Indirect Cost Data

Indirect costs are due to morbidity and premature mortality. Mortality costs were determined from the SEER survival database. Calculation of lifetime earnings lost were estimated using data from D. Rice (Prof. Emeritus, UCSF, Institute for Health and Aging, written communication, April 30, 1997). An average annual increase of 1% in wage-earner productivity was used. Earnings and labor force participation rates were from the Bureau of Labor Statistics. The 1994–1995 Employment Cost Index was used to update costs to 1996 estimates of productivity losses [31]. Household work for men and women was determined using Peskin's method, which averaged the time spent keeping house [32]. The present value of total mortality costs were calculated using discount rates of 3% (base and low case) and 5% (high case).

Morbidity costs are the value of lost employment and lost activity days, which were obtained by pooling multiple years of the NHIS annual estimates of employed and unemployed persons with pancreatic cancer. It was assumed that everyone employed at the time of diagnosis with pancreatic cancer would lose his/her job in that year, evenly distributed across that year.

Bed days and activity loss days for the unemployed were estimated from NHIS data and were valued as opportunity cost loss days. Activity loss days were valued for both men and women and for all ages at the housekeeping wage rate in 1994 and inflated to 1996 using the Consumer Price Index for wages [33]. Relative standard errors (RSEs) were calculated and the confidence intervals around the means (base case) were used to calculate the high and low cases.

RESULTS

Epidemiology

The estimated annual U.S. period prevalence rate in 1996 is 15.7/100,000 (41,637), and the point prevalence rate is 4.7/100,000 (12,562). Estimated incidence is 29,075 (11/100,000). There were 29,409 deaths in 1996. (Figs. 1 and 2, respectively).

Total Utilization and Costs

The total cost of pancreatic cancer was $4.9 billion, $881 million in direct costs and $4.0 billion in indirect costs (Tables I and II). Indirect costs, primarily early mortality, accounted for most of the cost burden (82%: $4,018 M/$4,899 M). Hospitalization costs accounted for 77% ($679.5 M/$881.3 M) of the direct costs; long-term care, medications, and hospice accounted for the next

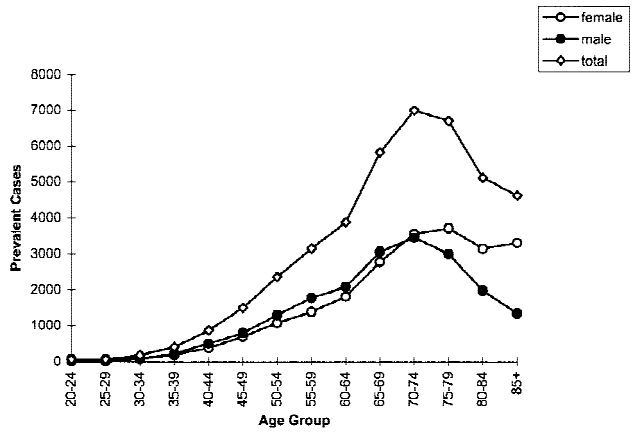

Fig. 1. Annual period prevalence of pancreatic cancer by age group and gender.

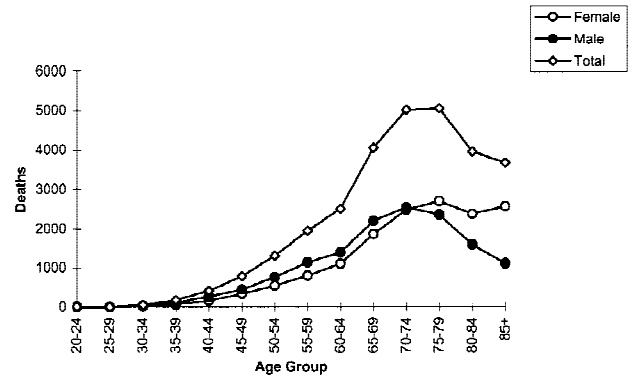

Fig. 2. Pancreatic cancer annual deaths by age group and gender.

largest proportions of 7% ($66.0 M/$881.3 M), 6% ($52.4 M/$881.3 M), 5% ($48.4 M/$881.3 M), respectively. The total economic burden was highest for the middle age group, accounting for 56% ($2,740 M/$4,899 M) of the total costs—despite a higher prevalence in the elderly, which account for 70% (29,220/41,637) of prevalent cases. Those over 65 years accounted for 71% ($627.1 M/$881.3 M) of the direct costs, while the middle age group accounted for 25% ($222 M/$881.3 M) of direct costs. The middle age group, in their prime productive years, accounted for 69% ($193.9 M/$279.35 M) of the morbidity costs. While direct costs were almost the same between genders, indirect costs of men were about 66% ($998 M/$1,510 M) greater than those of women, primarily due to differences in employment rates and wages.

Hospitalization

Total hospitalization costs were $680 million and accounted for 77% ($679.5 M/$881.3 M) of total direct costs, and 14% ($679.5 M/$4,899 M) of total costs. There were 61,074 hospitalizations annually with any diagnosis of pancreatic cancer in the base case. There were 1.5 hospitalizations per period prevalent case, or 2.1 per incident case. Hospital physician cost per visit averaged $55, or $524 for each hospitalization, representing a small proportion (5%: $32 M / $679.5 M) of total hospital costs.

Most hospitalized pancreatic patients were Medicare admissions (59%: 656/1,120), and others were Title V or other government insured (23%: 258/1,120), Blue Cross Blue Shield (BCBS) (12%: 129/1,120), Medicaid (4%: 46/1,120), and other community insurance (2%: 25/1,120). Medicare patients had the highest hospital costs per admission ($11,583), while BCBS and Medicaid patients had similar costs ($9,497 and $9,936, respectively). Room and board costs were the major portion of total hospital costs per admission (45%: $4,993/$11,055). Operating room costs were 9% ($1,045/$11,055) of total hospital costs per admission, about the same as 9% ($1,016/$11,055) for radiology and 10% ($1,052/$11,055) for laboratory costs, and less than the 11% ($1,213/$11,055) for medications. The Maryland data show that 74.8% (838/1,120) of hospitalizations included no major pancreatic procedure, defined as bypass or cancer-directed surgery (Table III). Of pancreatic cancer hospital admissions, 10.7% (120/1,120) were for a Whipple procedure, 1.7% (19/1,120) for laparotomy, 1.0% (11/1,120) for total pancreatectomy, and 1.1% (12/1,120) for a distal pancreatectomy. The average total costs for admissions with major surgery were more than three times greater than for those without major surgery ($22,546 and $7,188, respectively).

Hospitalization rates decreased, and cost per hospitalization increased with age (Tables I and II). The young age group accounted for only 2,946 hospitalizations (1.9 per period prevalent case), the middle age group 18,014 (1.7 per period prevalent case), and the elderly for 40,114 (1.4 per period prevalent case).

The elderly accounted for the largest total hospital cost and cost per admission. Costs per admission were $11,614, $10,346, $8,962 for the old, middle, and young age groups, respectively. The elderly accounted for 68% ($464.5 M/$679.5 M) of total hospital plus hospital physician visit costs, the middle age group, 28% ($187.7M/$679.5 M); and the young, 4% ($27.5 M/$679.5 M).

For the base case, men had more hospitalizations than women (32,935 versus 28,137) and had a higher hospitalization rate (1.7 versus 1.3 per prevalent case, respectively). This is despite a higher disease prevalence in women (53%: 22,168/41,637), and an equal or even slightly higher proportion of women being diagnosed at stage 1 or 2, where surgery is more likely to be beneficial [3]. More hospitalizations may mean that men are having more surgeries and procedures, or are sicker than women. Men's and women's hospital costs per admission ($10,877 for women and $11,206 for men) and operating room costs, however, were about the same, and the

TABLE I. Total Direct and Indirect Cost of Pancreatic Cancer by Age and Gender

	Total	Males	Females	<45 years	45–64 years	65+ years
Total costs in millions	$4,899.00	$2,962.00	$1,937.00	$690.000	$2,740.000	$1,471.00
Total direct	$ 881.30	$ 454.40	$ 426.74	$ 34.080	$ 222.020	$ 627.10
Total hospital	$ 679.50	$ 359.88	$ 319.37	$ 27.500	$ 187.700	$ 464.50
Hospital	$ 647.50	$ 343.57	$ 303.94	$ 26.400	$ 178.800	$ 442.30
MD visits	$ 32.00	$ 16.30	$ 15.40	$ 1.100	$ 8.900	$ 22.20
MD outpatient	$ 8.30	$ 3.90	$ 4.44	$ 0.320	$ 2.200	$ 5.90
Laboratory	$ 3.90	$ 1.80	$ 2.06	$ 0.350	$ 1.100	$ 2.70
Medications	$ 52.40	$ 24.53	$ 27.93	$ 1.970	$ 13.700	$ 36.80
Medical equip.	$ 9.40	$ 4.41	$ 5.02	$ .640	$ 2.200	$ 6.60
Personal care	$ 2.10	$ .99	$ 1.13	$ .120	$ .520	$ 1.50
Hospice	$ 48.40	$ 22.77	$ 25.68	$ 1.800	$ 12.600	$ 33.90
Home care	$ 11.20	$ 5.24	$ 5.96	$ 0.028	$ 2.000	$ 9.20
Long-term care	$ 66.00	$ 30.87	$ 35.15	$ 0.000	$ 0.000	$ 66.00
Total indirect	$4,018.00	$2,508.00	$1,510.00	$655.750	$2,518.430	$ 844.08
Total morbidity	$ 279.35	$ 192.10	$ 87.24	$ 13.950	$ 193.900	$ 71.48
Work loss	$ 258.70	$ 186.40	$ 72.28	$ 13.110	$ 190.100	$ 55.51
Bed days lost	$ 17.58	$ 4.84	$ 12.75	$ .717	$ 3.260	$ 13.61
Non-bed days lost	$ 3.05	$ .84	$ 2.21	$ .124	$ .570	$ 2.36
Total mortality	$3,739.00	$2,316.00	$1,423.00	$641.800	$2,234.500	$ 772.60

TABLE II. Total Direct and Indirect Cost per Period Prevalent Case With Pancreatic Cancer by Age and Gender

	Total	Males	Females	<45 years	45–64 years	65+ years
Total costs	$117,684	$152,188	$87,378	$440,365	$252,553	$50,348
Total direct	$ 21,168	$ 23,343	$19,250	$ 21,088	$ 20,461	$21,461
Total hospital	$ 16,321	$ 18,488	$14,407	$ 17,583	$ 17,298	$15,897
Hospital	$ 15,552	$ 17,650	$13,711	$ 16,880	$ 16,478	$15,137
MD visits	$ 769	$ 837	$ 695	$ 703	$ 820	$ 760
MD outpatient	$ 199	$ 200	$ 200	$ 205	$ 203	$ 202
Laboratory	$ 94	$ 92	$ 93	$ 224	$ 101	$ 92
Medications	$ 1,259	$ 1,260	$ 1,260	$ 1,260	$ 1,263	$ 1,259
Medical equip.	$ 226	$ 227	$ 226	$ 409	$ 203	$ 226
Personal care	$ 50	$ 51	$ 51	$ 77	$ 48	$ 51
Hospice	$ 1,163	$ 1,170	$ 1,158	$ 1,151	$ 1,161	$ 1,160
Home care	$ 269	$ 269	$ 269	$ 179	$ 184	$ 315
Long-term care	$ 1,585	$ 1,586	$ 1,586	$ 0	$ 0	$ 2,259
Total indirect	$ 96,516	$128,845	$68,128	$419,277	$232,092	$28,887
Total morbidity	$ 6,710	$ 9,868	$ 3.936	$ 8,919	$ 17,872	$ 2,446
Work loss	$ 6,214	$ 9,576	$ 3,261	$ 8,382	$ 17,519	$ 1,900
Bed days lost	$ 422	$ 249	$ 575	$ 458	$ 300	$ 466
Non-bed days lost	$ 73	$ 43	$ 100	$ 79	$ 53	$ 81
Total mortality	$ 89,806	$118,977	$64,192	$410,358	$214,220	$26,441

length of stay of women was 1 day longer than men (9.9 versus 8.8 days, respectively, *P*-value >.05, two-tailed test), suggesting about the same or greater illness intensity in women than in men. Additionally, the Maryland data showed that for the middle and elderly groups taken together, women were less likely than men to have cancer-directed surgery (odds ratio for women versus men = 0.70, 95% CI = 0.49, 1.00) (Table III). Therefore, these estimates suggest that despite women being diagnosed at an equal or slightly earlier stage, women had fewer hospitalizations and fewer admissions for cancer-directed surgery than men. Additionally, elderly women were less likely to have stents placed than men (odds ratio for women versus men having stents placed = 0.43, 95% CI = 0.26, 0.73) (Table III), which is consistent with earlier diagnosis. It may be that fewer women are cared for in hospitals rather than at home, are receiving less aggressive treatment, and/or are choosing palliative care more often.

Additional cost estimates for detailed procedures identified by ICD-9 code are shown in Table IV. Pancreaticoduodenectomy is by far the most frequent curative surgery performed in Maryland, while gastroenterostomy is the most frequent bypass operation.

Outpatient Costs

Total outpatient costs were $76.1 million or only 1.6% ($76.1 M/$4,899 M) of all costs or 9% ($76.1 M/$881.3

TABLE III. Number of Admissions and Cost per Person for Hospital Procedures for Pancreatic Cancer

	<45 years		45–64 years		>64 years	
Hosptial procedure (n)	Number (%)	Cost per admit	Number (%)	Cost per admit	Number (%)	Cost per admit
Bypass surgery (139)[a]						
Females	4 (3)	$ 8,890	20 (14)	$18,465	58 (42)	$20,572
Males	1 (1)	$28,507	25 (18)	$15,320	31 (22)	$19,877
CA-directed surg. (143)[b]						
Females	4 (3)	$18,971	23 (16)	$20,578	41 (29)	$27,629
Males	2 (1)	$12,919	27 (19)	$22,092	46 (32)	$26,406
Laparotomy (19)						
Females	0 (0)	—	4 (21)	$10,691	6 (32)	$ 8,567
Males	1 (5)	$16,829	5 (26)	$14,399	3 (16)	$18,258
Stent (107)						
Females	0 (0)	—	25 (23)	$ 8,344	25 (23)	$ 8,740
Males	2 (2)	$ 5,997	15 (14)	$11,437	40 (37)	$ 8,863
No procedure (191)						
Females	5 (3)	$ 2,666	27 (14)	$ 3,122	77 (40)	$ 4,393
Males	4 (2)	$ 2,278	29 (15)	$ 2,853	49 (26)	$ 3,214
Panc. diagnostics (245)[c]						
Females	4 (2)	$ 7,817	40 (16)	$ 8,148	98 (40)	$ 7,465
Males	5 (2)	$10,456	36 (15)	$ 7,135	62 (25)	$ 8,092
Other Diagnostics (133)						
Females	2 (2)	$26,031	22 (17)	$ 9,599	42 (32)	$ 7,948
Males	4 (3)	$ 7,359	26 (20)	$ 7,320	37 (28)	$ 6,323
Other (143)						
Females	5 (3)	$ 7,767	26 (18)	$ 6,243	46 (32)	$ 9,071
Males	13 (9)	$ 4,922	27 (19)	$ 5,167	26 (18)	$ 6,141

[a]Bypass surgery is noncancer-directed surgery or gastrostomy, duodenostomy, cholodochoenterostomy, and gastro-intestinal anastomoses.
[b]Cancer-directed surgery is total and distal pancreatectomy and pancreaticoduodenectomy (Whipple).
[c]Panc. Diagnostics is pancreas-directed diagnostics or ERCP, ERC, ERP, aspiration biopsy on pancreas, endoscopic ERP, diagnostic procedures on biliary tract.

M) of total direct costs (Table I). Medications accounted for $52.4 million, or 69% ($52.4 M/$76.1 M) of total outpatient costs. Patients had an average of 3.6 physician visits per period prevalent case annually (5.2/incident case), or 151,570 visits.

Home, Hospice, and Long-Term Care Costs

Home, hospice, and long-term care costs together were the second largest proportion (14%: $125.6 M/$881.3 M) of direct health care costs, and 2.6% ($125.6 M/$4,899 M) of total costs (Table I).

The total hospice costs were $48.4 million, with an average reimbursement per patient of $6,211. Their average cost per pancreatic cancer patient in hospices was $14,311. The average cost was $73 per day with a mean stay of 59 days. The average cost per period prevalence was $1,163 and per incidence was $1,666. The assumption that the same rate of hospice was used for all ages led to the group with the highest prevalence accounting for most hospice care. Hospice care cost the most for the elderly age group, with $33.9 million annually (7,866 visits). Care for the middle age group cost $12.6 million (2,992 visits), and $1.8 million (427 visits) for the young group.

Home care cost $11.2 million. Home care cost was $27,560 for the young, $2 million for the middle age group, and $9.2 million for the old age group. The elderly incurred almost twice the home care costs per period prevalent case ($315) than the middle age group ($184).

There were 11,559 long-term care stays by pancreatic cancer patients that cost $66 million ($30.87 million for men and $35.15 million for women). This was $1,585 per period prevalent case and $2,371 per incident case.

Indirect Costs

Total indirect costs, due to morbidity and early mortality, were $4.0 billion and accounted for the majority (82%: $4,018 M/$4,899 M) of total costs (Table I). Mortality losses were 93% ($3,739 M/$4,018 M) of indirect costs. Indirect costs were highest for the middle age group, $2.5 billion (63%: $2,518.43 M/$4,018 M) and about equal for those in the young and old age groups ($655 million and $844 million, respectively). The mortality cost for the middle age group was $2,325 million

TABLE IV. Cost per Admission and Detailed Surgical Procedures for Pancreatic Cancer (in 1995 Dollars)

ICD-9	Description	No.	Mean	S.E.
	Cancer-directed surgery			
52.51	Proximal pancreatectomy-duodenectomy	1	23,318	—
52.52	Distal pancreatectomy	12	31,612	9,126
52.53	Pancreaticoduodenectomy: subtotal	2	32,215	3,195
52.6	Total pancreatectomy	11	22,129	2,459
52.7	Pancreaticoduodenectomy	117	24,965	2,192
	Bypass and anastomosis procedures			
43.11	Percutaneous endoscopic gastrostomy	10	10,560	2,364
43.19	Other gastrostomy	4	19,360	2,888
44.39	Gastroenterostomy bypass	90	20,281	1,349
46.39	Duodostomy, feeding enterostomy	9	22,574	4,141
51.32	Anastomosis gallbladder/intestine	11	16,579	2,683
51.36	Cholodochoenterostomy	13	15,136	2,630
51.37	Anastomosis hepatic duct to gastrointestinal tract	2	17,533	2,572
	Laparotomy			
54.11	Exploratory laparotomy	16	12,869	1,558
54.19	Other laparotomy	3	10,622	3,142
	Stents and prosthetic devices			
51.43	Cholodochohepatic tube	10	9,490	1,772
51.87	Place stent	53	7,987	731
51.95	Biliary prosthesis: removal	1	14,779	—
51.99	Biliary prosthesis: insert or replace	6	10,405	3,749
97.05	Biliary prosthesis: replacement	37	9,994	2,496

(62% of total mortality costs: $2,324.5 M/$3,739 M). Mortality costs per death for the elderly were $35,022; for the middle age group, $332,508, and for the young age group, $937,268. The large societal cost for the middle age group despite the low prevalence of disease is important. Men's expected mortality costs were almost double those of women ($2,316 M versus $1,423 M) primarily due to differences in wages. The cost per death (Table V) for men was $163,000, while only $94,000 for women. The mortality cost burden decreased to $3.3 billion with a 5% discount rate and to $2.5 billion with a 10% discount rate.

Morbidity costs ($279 million) accounted for only 7% ($279.35 M/$4,018 M) of total indirect costs (Tables I and II). The middle age group had the highest morbidity costs due to work loss days. The elderly had about four times more bed day and activity day costs than the middle age group. Morbidity costs were higher for males than females, due primarily to work loss cost, which was 93% ($258.7 M / $279.35 M) of total morbidity costs.

Sensitivity Analyses

The results presented above are point estimates of mean costs for the base case, using what we considered to be the best estimates available for each cost category for different ages and genders. Nonsampling error was more important than sampling error in providing accurate cost estimates. The selection of representative databases, the determination of the appropriate discount rate, and choice of wage rates for women and men in the calculation of indirect costs had the most effect on the estimates of total cost.

Three different types of sensitivity analyses were performed. First, the joint effect of using high and low estimates derived from different data sources on total costs were estimated where cost estimates were available from multiple data sources, but pooling was not appropriate. Then the best estimate was used for the base case and the lowest and highest available estimates (as described previously) were used for the bounds for the sensitivity analysis (Table VI). The effect of different discount rates on mortality costs was also included in this analysis. Total costs differed by from 2% ($108 M/$4,899 M) to 12% ($580 M/$4,899 M) from the base case. Total indirect costs ranged from $3.5 to $4.0 billion. Direct costs ranged from $777 to $964 million, and differed from the base case by only 12% ($104.1 M/$881.3 M) for the lower and 9% ($82.6 M/$881.3 M) for the higher cost case (Table VI).

The effect of using different data sources for hospital utilization was examined in detail because it is the largest component of direct costs. Estimates for hospital services were fairly consistent across databases. Utilization ranged from 55,283 to 66,864 hospitalizations annually, or 1.3 to 1.6 per period prevalent case. Average costs per hospitalization in the base case averaged $10,602, with low and high estimates differing by 5% ($513/$10,602) to 0.3% ($33/$10,602), respectively. After stratification by age group, the average Medi-Cal costs per hospitalization were similar to the base case ($9,980). Medicare

TABLE V. Mortality Costs: Present Value of Lifetime Earnings Lost to Pancreatic Cancer by Age and Gender

Age	Number of deaths	Years lost	Amount + 3% discount rate (in thousands)	Cost per death (in thousands)	Amounts (in thousands) Discount Rates 5%	10%
Total	29,409	407,594	$3,739,001	$ 127	$3,274,496	$2,496,744
20–24	14	867	$ 15,482	$1,028	$ 10,954	$ 5,706
25–29	11	512	$ 9,633	$ 993	$ 7,129	$ 4,016
30–34	61	2,710	$ 67,629	$1,135	$ 51,943	$ 30,892
35–39	183	7,293	$ 183,249	$1,017	$ 146,166	$ 92,876
40–44	418	14,785	$ 365,819	$ 869	$ 302,092	$ 204,205
45–49	772	23,938	$ 528,697	$ 680	$ 450,232	$ 322,687
50–54	1,413	37,661	$ 701,500	$ 436	$ 613,500	$ 463,023
55–59	2,022	45,765	$ 645,900	$ 320	$ 577,072	$ 455,094
60–64	2,519	47,653	$ 449,442	$ 178	$ 405,569	$ 327,731
65–69	4,020	62,173	$ 366,249	$ 91	$ 331,805	$ 273,727
70–74	5,013	62,129	$ 228,412	$ 45	$ 209,416	$ 173,171
75–79	5,191	50,061	$ 121,258	$ 23	$ 112,718	$ 95,754
80–84	4,032	29,387	$ 45,751	$ 12	$ 43,184	$ 37,749
85+	3,742	22,560	$ 10,977	$ 3	$ 10,714	$ 10,112
Men						
Total	14,199	191,224	$2,316,205	$ 163	$2,034,920	$1,558,797
20–24	0	0	$ 0	$ 0	$ 0	$ 0
25–29	0	0	$ 0	$ 0	$ 0	$ 0
30–34	36	1,500	$ 44,617	$1,254	$ 34,255	$ 20,268
35–39	108	4,068	$ 122,936	$1,140	$ 98,236	$ 62,403
40–44	267	8,883	$ 261,920	$ 980	$ 217,022	$ 147,267
45–49	454	13,145	$ 356,100	$ 783	$ 304,894	$ 220,271
50–54	831	20,493	$ 469,871	$ 566	$ 413,834	$ 316,075
55–59	1,174	24,320	$ 417,513	$ 356	$ 376,286	$ 301,714
60–64	1,409	24,111	$ 263,918	$ 187	$ 240,649	$ 197,665
65–69	2,184	30,205	$ 195,556	$ 90	$ 179,312	$ 148,881
70–74	2,541	27,777	$ 108,695	$ 43	$ 100,008	$ 83,290
75–79	2,433	20,504	$ 53,728	$ 22	$ 50,108	$ 42,865
80–84	1,628	10,306	$ 17,732	$ 11	$ 16,783	$ 14,767
85+	1,138	5,912	$ 3,617	$ 3	$ 3,530	$ 3,331
Women						
Total	15,210	216,370	$1,422,796	$ 94	$1,239,576	$ 937,947
20–24	14	867	$ 15,482	$1,028	$ 10,954	$ 5,706
25–29	11	512	$ 9,633	$ 933	$ 7,129	$ 4,016
30–34	25	1,210	$ 23,012	$ 917	$ 17,688	$ 10,624
35–39	75	3,225	$ 60,313	$ 810	$ 47,930	$ 30,473
40–44	151	5,902	$ 103,899	$ 681	$ 85,070	$ 56,938
45–49	318	10,793	$ 172,597	$ 542	$ 145,338	$ 102,416
50–54	582	17,168	$ 231,629	$ 398	$ 199,666	$ 146,948
55–59	848	21,445	$ 228,387	$ 269	$ 200,786	$ 153,380
60–64	1,110	23,542	$ 185,524	$ 166	$ 164,920	$ 130,066
65–69	1,836	31,968	$ 170,693	$ 93	$ 152,493	$ 124,846
70–74	2,472	34,352	$ 119,717	$ 48	$ 109,408	$ 89,881
75–79	2,758	29,557	$ 67,530	$ 24	$ 62,610	$ 52,889
80–84	2,404	19,081	$ 28,019	$ 12	$ 26,401	$ 22,982
85+	2,604	16,648	$ 7,360	$ 3	$ 7,184	$ 6,781

costs for those over 64 years old were somewhat higher ($10,438), but were similar to the Maryland costs for this age group ($11,614).

Second, the effect of sampling error on base case "best" estimates was determined. Standard errors, when available, were used to conduct a one-way sensitivity analysis. The standard error (SE) for the Maryland data mean cost per admission was $402 (95% CI = $10,251 to $11,859) per admission. The SE for total activity days lost was 298,534 (RSE = 0.24) (mean = 1,242,705, 95% CI = 657,578 to 1,827,832). Morbidity costs were estimated using pooled rates from annual NHIS survey data from 1988 to 1994. The RSE for total bed days was 0.28 and the pooled SE was 299,026 (mean = 1,059,107, 95% CI = 473,017 to 1,645,198). Only estimates which had RSE < 0.3 were used for the estimates.

Third, alternate assumptions on appropriate wage rates

TABLE VI. Sensitivity Analyses: Total Costs of Pancreatic Cancer (in Millions)*

	Low case	Base case	High case
Total costs	$4,319.0	$4,899.0	$5,007.0
Total direct costs	$ 777.2	$ 881.3	$ 963.9
Total hospital	$ 589.8	$ 679.5	$ 743.1
Hospital	$ 557.8	$ 647.5	$ 711.1
Physician	$ 32.0	$ 32.0	$ 32.0
Total MD	$ 6.5	$ 8.3	$ 10.2
Laboratory	$ 3.0	$ 3.9	$ 3.9
Medications	$ 52.4	$ 52.4	$ 59.7
Medical equipment	$ 7.2	$ 9.4	$ 9.4
Personal care	$ 1.6	$ 2.1	$ 2.1
Hospice	$ 48.4	$ 48.4	$ 48.4
Home care	$ 2.3	$ 11.2	$ 20.1
Long-term care	$ 66.0	$ 66.0	$ 67.0
Total indirect costs	$3,542.0	$4,018.0	$4,043.0
Morbidity	$ 268.0	$ 279.0	$ 304.0
Mortality	$3,274.0	$3,739.0	$3,739.0

*Numbers may not add up due to rounding.

were used to conduct a sensitivity analysis for indirect costs for women's mortality costs. Mortality costs from work loss were calculated for women using men's wage rates. This increased the mortality costs for women to $1.75 billion, an increase of 23% ($327 M/$1,423 M) over the base case women's mortality cost and 9% ($327 M/$4,899 M) for total costs, the largest single effect of sensitivity estimates.

The effect of sampling errors on the base case was minor, because parameters with high RSEs for services such as hospitalization were excluded from these estimates. However, the effect of using different sources for estimates of hospital episodes was more important and was captured in the ranges around the base case.

DISCUSSION

Pancreatic cancer is a significant economic burden to society primarily due to the early mortality of the disease, which accounts for 93% ($3,739 M/$4,018 M) of total indirect costs. Of five major digestive cancers, pancreatic cancer has the second highest total cost per incident case, with only esophageal cancer costing more [15,16]. The current cost literature focuses on direct medical costs, yet these costs are a relatively small part of total costs. Although there is concern by clinicians that needless procedures are being performed, this study shows that no major procedure is being performed for the majority of hospital admissions, although the costs of surgical admissions are three times greater than nonsurgical. The middle age group had the highest total and indirect costs while the elderly had the largest direct cost. Our data show that women have fewer hospitalizations and fewer cancer-directed surgeries than do men. While we do not have gender-specific population data on surgical rates, it may be that women are having proportionally fewer cancer-directed surgeries and these gender differences should be examined in future studies.

The indirect costs estimated here are higher than those previously reported. Brown and Everhart, the other known study of the total costs of pancreatic cancer, reported total costs (inflated from 1985 to 1996 dollars) of $2.6 billion ($1.1 billion direct and $1.5 billion indirect costs) [15], which is lower than our total estimate of $4.9 billion. The difference is primarily due to our larger mortality costs. Brown and Everhart exclude the value of leisure time and male and female labor in the home, as well as the 1% per year productivity growth in the calculation of mortality costs [15], and acknowledge that their cost estimates are generally lower than others [15]. Our mortality cost methods are more realistic, allow a more equitable treatment of men's and women's labor [34–36], and are used frequently to estimate mortality costs [34–39]. In addition, they are still conservative since they are based on present value of lifetime earnings lost. Brown and Everhart [15] do not report the mortality estimates used for their costs. Our annual deaths of 29,409 are similar to Boring, who reported more than 27,000 people dying from pancreatic cancer in 1994 [40]. Also, the years of life lost per death are comparable to those reported for other cancers [41].

A limitation of the analysis is the inclusion of both endocrine and exocrine pancreatic cancers in the estimates. This was done to arrive at the most accurate total cost figure given the availability of both epidemiological and cost data. Most aggregate and survey data do not differentiate between endocrine and exocrine utilization and costs. Therefore it is important to apply a combined prevalence to calculate costs per prevalent case. Exocrine cancer alone has a period prevalence between 37,636 and 39,736: an average decrease of 7% (2,951/41,637) from the period prevalence of all pancreatic cancer. However, the effect of inclusion of endocrine cancer on the specific cost estimates is unknown. For direct costs, endocrine disease may be as resource intensive as exocrine, but over a longer time period. For indirect costs, endocrine patients have higher survival rates but contract the disease at an earlier age on average, so the effect on mortality costs is also ambiguous. Therefore, by reporting total pancreatic cancer costs, we report more accurate but somewhat less precise costs, and with per-patient costs that are accurate for the overall diagnosis of pancreatic cancer, but may be up to 10% too low or too high for total exocrine cancer costs alone.

These analyses provide cost rather than charge estimates for pancreatic cancer by service, age group, and gender. We combine micro-costing with detailed disease-specific macro-costing using national and regional cost data rather than single institution micro-costing, consider

the assumptions behind incidence- and prevalence-based approaches to costing, and perform sensitivity analyses for both sampling and nonsampling error.

The epidemiology of pancreatic cancer required that we combine two approaches to costing. Micro- and macro-cost methodologies were combined because of the low prevalence of the disease in order to achieve both accurate (internally valid) and representative (externally valid) cost estimates. Much of the current cost literature relies on single facility estimates allowing precise estimates which may not be representative. Our study relies on large secondary databases that we match to the age groups that they represent. These factors result in costs with greater generalizability than single institution costs.

Our examination of the assumptions behind incidence- and prevalence-based approaches to costing led to the use of period prevalence. Most current studies of cost burden use either a point prevalence (chronic disease) or an incidence (acute disease) approach. However, for pancreatic cancer, which has both chronic and acute features, the use of traditional prevalence measures, such as point prevalence, will mean that incident cases dying within the first year after diagnosis will be excluded. Therefore, with the low 1-year survival rate (about 19%), [42] the traditional calculations of cost per prevalent case will seriously overestimate the cost per diagnosis.

Consideration of both sampling and nonsampling error is especially important in calculating precise and unbiased estimates of utilization and costs for pancreatic cancer and other rare diseases [43,44]. Several approaches were used to increase and/or describe the reliability of the cost estimates. Triangulation of databases, in which up to three to four different data sources were used to cross-check a single estimate, was used to determine consistent estimates by age and gender. Pooling estimates from annual surveys across multiple years (3 to 8 years in this paper) to increase the precision of the estimates was used for some data parameters. Calculations of standard errors and high and low range estimates across multiple databases were used in sensitivity analyses on uncertain variables.

The most significant use of the cost data presented here is to provide accurate and representative costs for the U.S. population that can be used in economic studies of alternative clinical treatments. In some cases, our cost estimates are significantly lower than the charges reported elsewhere, and this may have important implications for the cost effectiveness of surgical or other therapies, and may mean therapies are more cost-effective than have been reported previously. For example, Lea and Stahlgren [12] use charges for resection of $54,066 for the initial hospitalization (in 1995 dollars). Our estimated mean cost for initial hospitalization is $22,129. The cost per life-years saved of an initial hospitalization for resection versus no procedure used charge data and were reported as high as $67,000 (Lea and Stahlgren [12]), but would be about $35,000 using our cost estimates, assuming the same ratio of cost per admission to cost over the remaining years of life. The use of charge data instead of cost data makes this procedure appear less cost-effective compared to commonly used therapies for other diseases.

Cost of illness estimates continue to guide policy and medical care decisions and aid society's choices and research priorities, especially when calculated by disease and age group. They also are essential for estimating the potential payoff of new health programs and treatments. For pancreatic cancer, cost of illness estimates show that not only direct costs (the money actually spent) but indirect costs (production forgone) contribute to the cost burden of a disease. The direct costs of all diseases has generally been rising as a percent of total economic burden [45]. Hospital costs are the highest direct cost factor, and although surgical costs are high, most pancreatic cancer hospitalizations do not include a surgical procedure. However, diseases such as pancreatic cancer continue to have larger mortality costs than direct medical costs. The direct costs of pancreatic cancer are not particularly high, probably because of the relatively short survival period over which they are incurred. It is important to have accurate costs of procedures for use in cost-effectiveness analysis. Mortality costs, especially in the working population, contribute the most economic burden, and these costs are often overlooked. Additionally, the potential gender differences in proportions undergoing cancer-directed surgery requires further study.

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COMMENTARY

Studies of this type are useful in quantifying the cost of cancer. The authors speak of "earlier diagnosis" of pancreatic cancer. It should be noted that the efficacy of "earlier diagnosis" for pancreatic cancer has not been proven.

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